



*NATURAL RESOURCES CANADA - INVENTIVE BY NATURE*

# **Canadian Forest Service (CFS) Boreal Research and Monitoring Projects (selected examples)**

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**Natural Resources Canada, Canadian Forest Service**

**NASA-ABOVE/POLAR/Yukon workshop**

**May 16, 2016**



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# Natural Resources Canada Canadian Forest Service (CFS)

**Provides science and policy expertise and advice on national forest sector issues, working in close collaboration with the provinces and territories.**

## **Growth and Innovation: Rooted in Sustainable Forests**

### **Priorities:**

- **Support forest sector competitiveness**
- **Optimize forest value**
- **Advance environmental leadership**



# CFS-ABoVE – A long standing relationship

- **2008-2012 – Pre-ABoVE**
  - Contribution of CFS researchers to VurSAL White Paper
  - Dialogue and exploration of potential collaboration (CarboNA...)
  
- **2012-2015 – ABoVE planning phase (Science Plan)**
  - Membership of ABoVE Science Definition Team (Dr. J. Metsaranta, NoFC)
  - Coordination of contributions from CFS, NRCan sectors and other federal agencies (Dr. C. Ste-Marie, Ottawa)
  
- Organization and hosting of a meeting for the ABoVE science definition and management with 7 federal departments (Ottawa, Dec 2013)
  
- Continued dialogue and coordination with ABoVE management
  - Review of ABoVE proposals (Dr. D. Thompson, NoFC)

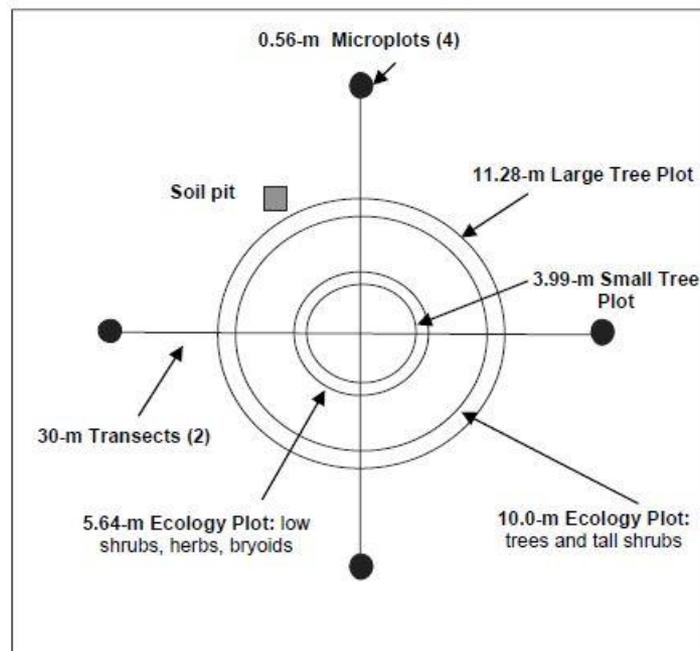


# The National Forest Inventory (NFI)

- A national sampling framework
- National definitions, standards and protocols
- Data management systems, collaboration tools, and information dissemination portal ([nfi.nfis.org](http://nfi.nfis.org))
- Field sampling survey (1,115 ground plots)
- Remote sensing survey (aerial photography, satellite data and lidar; 13,158 plots)



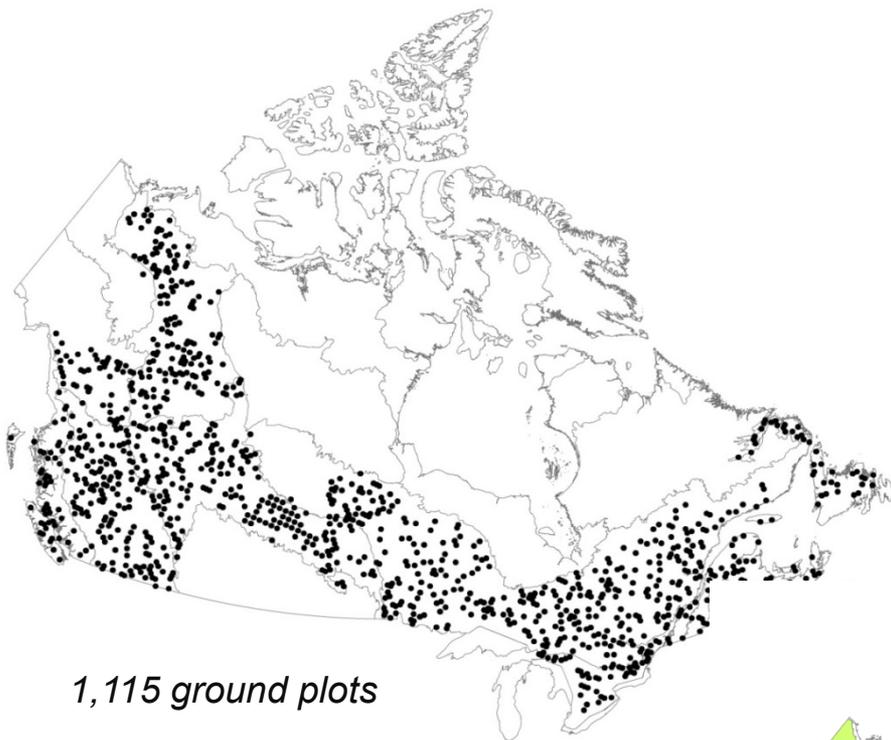
*Photo-interpreted survey plot (forest cover layer)*



*NFI ground plot layout*

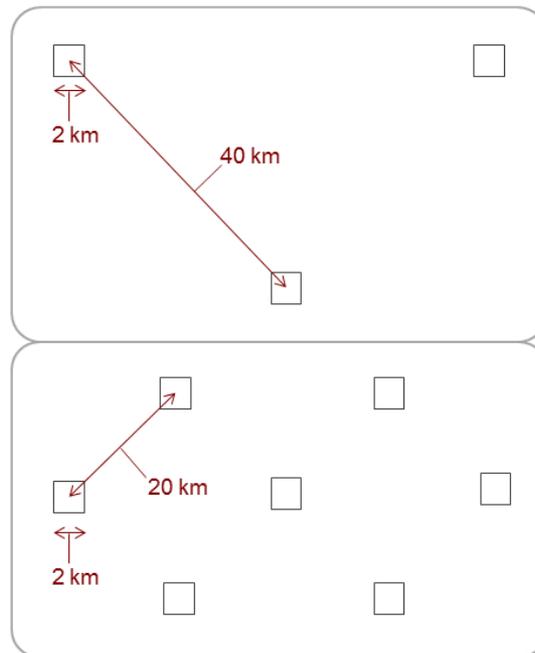


# NFI Remote sensing and ground plots



1,115 ground plots

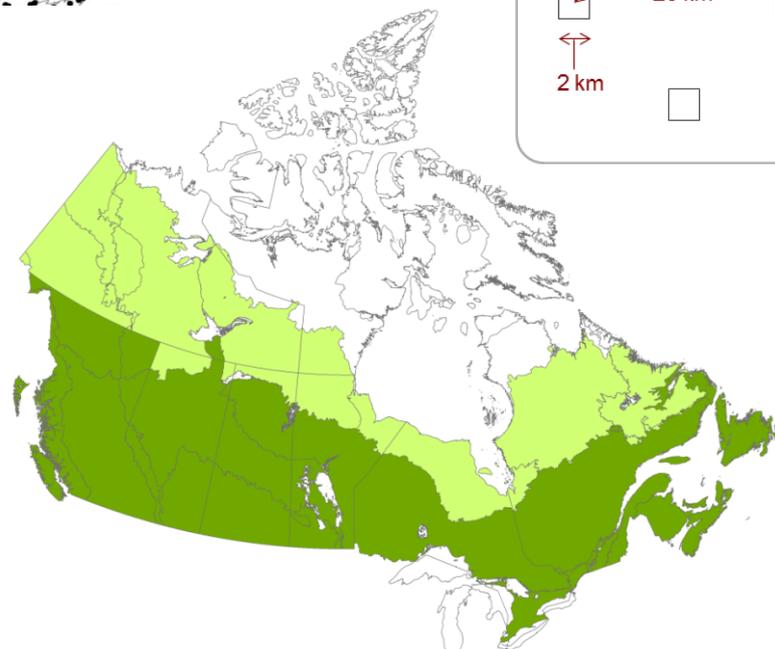
*Very high spatial resolution satellite survey covering 0.25% of light green zone*



*Photo-plot survey covering 1% of dark green zone*

Contact: Graham Stinson  
(PFC, Victoria)

Web site at: <https://nfi.nfis.org/>



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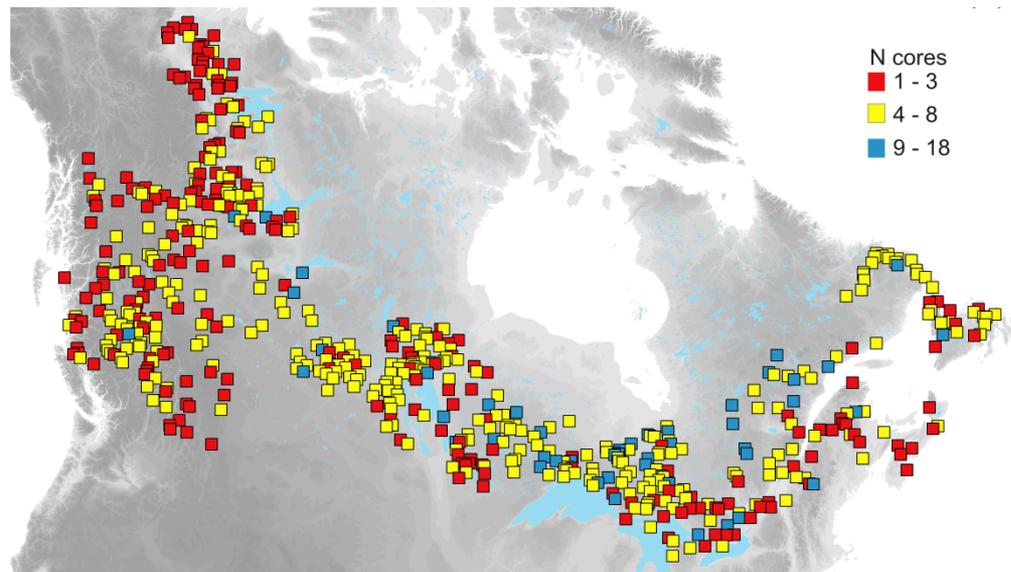
# NFI tree ring study (Girardin et al.)

## Sampling of 749 plots (2002-2010)

- >4300 increment cores collected from 58 tree species

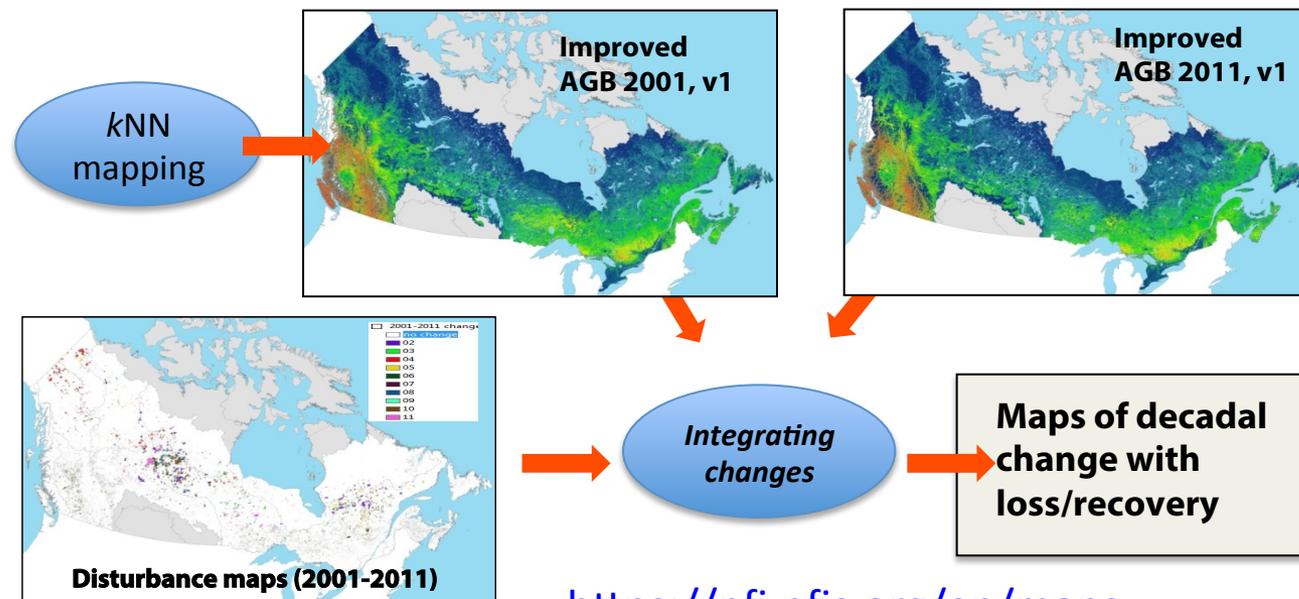
A valuable investment for tracking climate-related changes (past & future)

- Black spruce (31%)
- White spruce (8%)
- Trembling aspen (8%)
- Jack pine (6%)
- Balsam fir (6%)



# Mapping and monitoring Canada's forest properties using NFI data (A. Beaudoin et al.)

- **Geospatial data:**
  - 250 m MODIS time-series, 2001-2011 (CCRS)
  - LC, topo & climate features
- **MODIS-based methods:**
  - Improved temporal *k*NN predictions of NFI attributes (2001-2011)
  - Decadal differentiation of *k*NN predictions integrated with yearly disturbance maps (fires, harvest) (*Guindon et al., 2014, CJFR*): NFI attributes change with loss/recovery
- **Train/val:**
  - NFI photo-plots network/  
k-fold cross-val



*Beaudoin et al. (in prep)*

<https://nfi.nfis.org/en/maps>



# Mapping biomass (AGB) of northern boreal forests at 25 m based on multi-source EO

## Geospatial data: SAR/optical data at $\approx 25$ m res

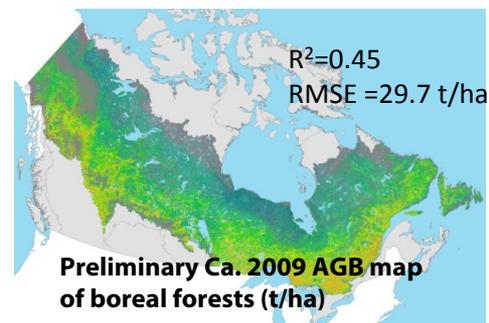
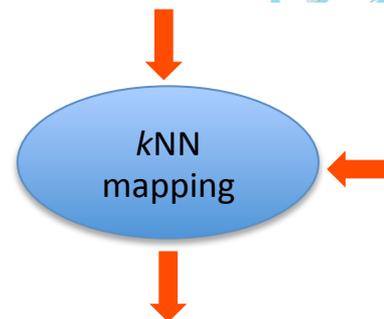
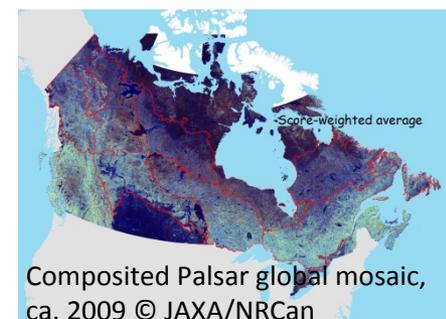
- L-band dual-pol JAXA PALSAR global mosaics (2007-2010, 2015 +); C-band Radarsat-2 (2013 +)
- Tree cover, topo, climate features
- Next: Landsat composites; Rsat-2 mosaics

## Train/val:

- Train: biomass surrogate sampling plots modeled from ICESAT-GLAS (Margolis et al., 2015, CJFR)
- Val: k-fold cross-val; independent inventory plots

## Methods:

- New PALSAR temporal compositing method
- kNN predictions within forest strata



Beaudoin et al. (in prep)



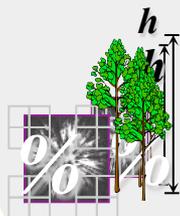
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# Integrating Remote Sensing & Field Data for Forest Inventory in the Northern Boreal (Hall et al.)

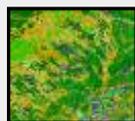
## 1. Field Data Collection



- Plot/tree level
- Tree ht, DBH
- Stand attributes:  
e.g.: Stand height, volume, crown closure, AGB

## 2. EOSD Land Cover

- Landsat imagery (c2007)
- Modelling stratification:



- *Conifer, Mixed*
- *Deciduous*
- *Non-forest*

## 3. LiDAR and Field Data Modeling



**Airborne LiDAR**

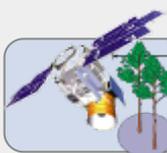
Stand Attributes:  
 $f[\text{LiDAR metrics}]$

Stand Attributes:  
 $f[\text{Stand/Lorey HT}]$

(limited coverage)

Overlay ICESat  
Airborne HT

Stand attributes =  
 $f[\text{ICESat HT}]$



**ICESat LiDAR**

Stand/Lorey HT:  
 $f[\text{ICESat metric,}]$

**k-NN:**  
*Stand Attributes Mapped  
by Scaling to Landsat*

## 4. Forest Vegetation Inventory Mapping

GIS Processing  
(raster to vector)



**GNWT Forest  
Inventory (FVI)**

**Satellite Veg  
Inventory (SVI)**

**Multi-Source  
Veg. Inventory  
(MVI)**

# Carbon Budget Modelling and Reporting (Kurz et al.)



Operational Scale Carbon Budget Model of the Canadian Forest Sector Release 1.0

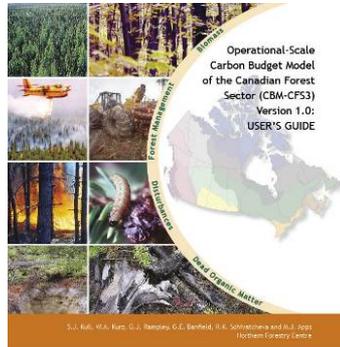


NATIONAL FOREST NETWORK  
RÉSEAU DE FORÊTS MODÈLES

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*“An operational to national-scale model of forest ecosystem C dynamics developed to assess the past, present and future role of the Canadian forests in the global C cycle.”*

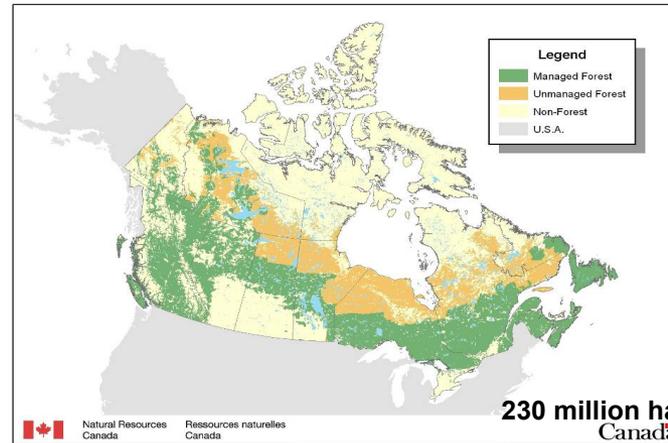


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## Canada's National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS)



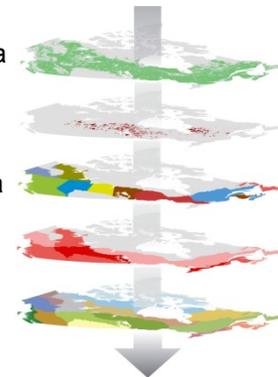
Forest inventory and growth & yield data

Natural disturbance monitoring data

Forest management activity data

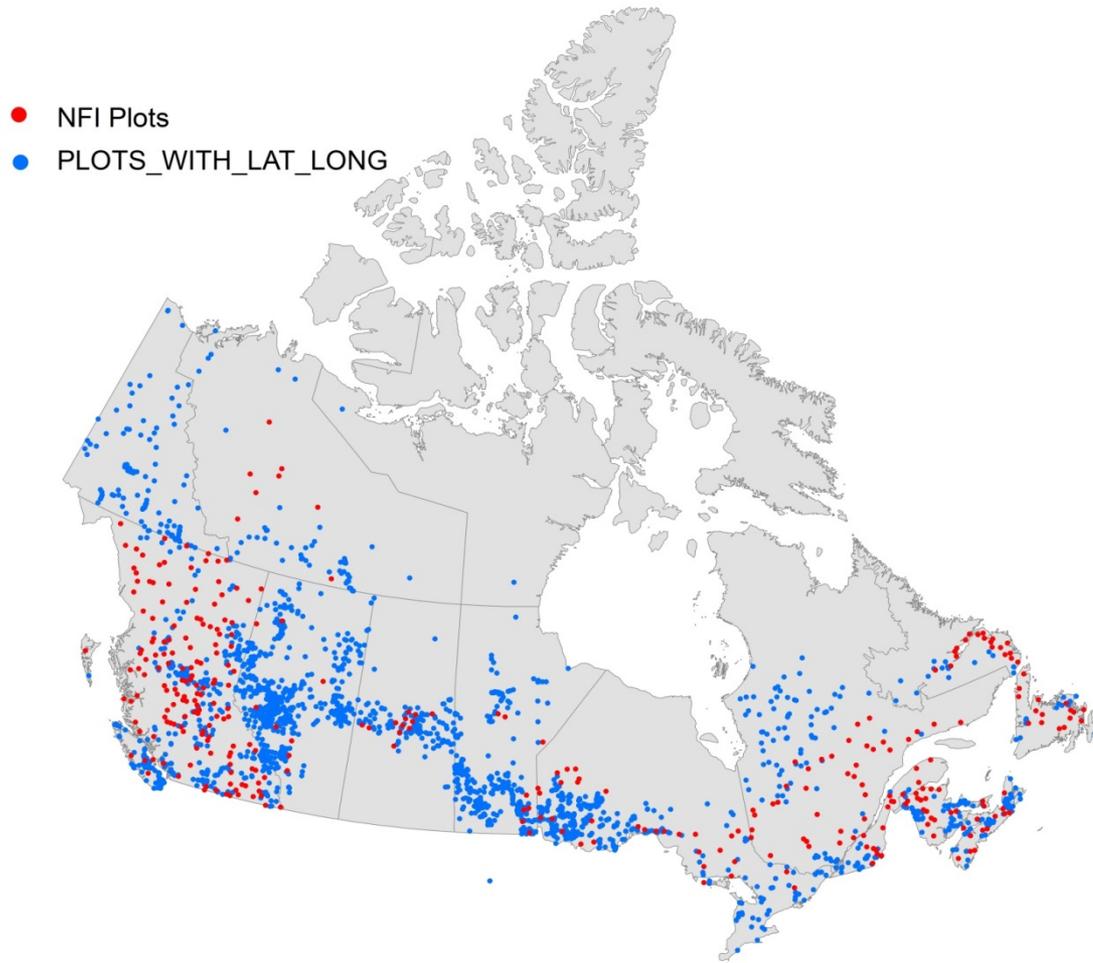
Land-use change data

Ecological modelling parameters

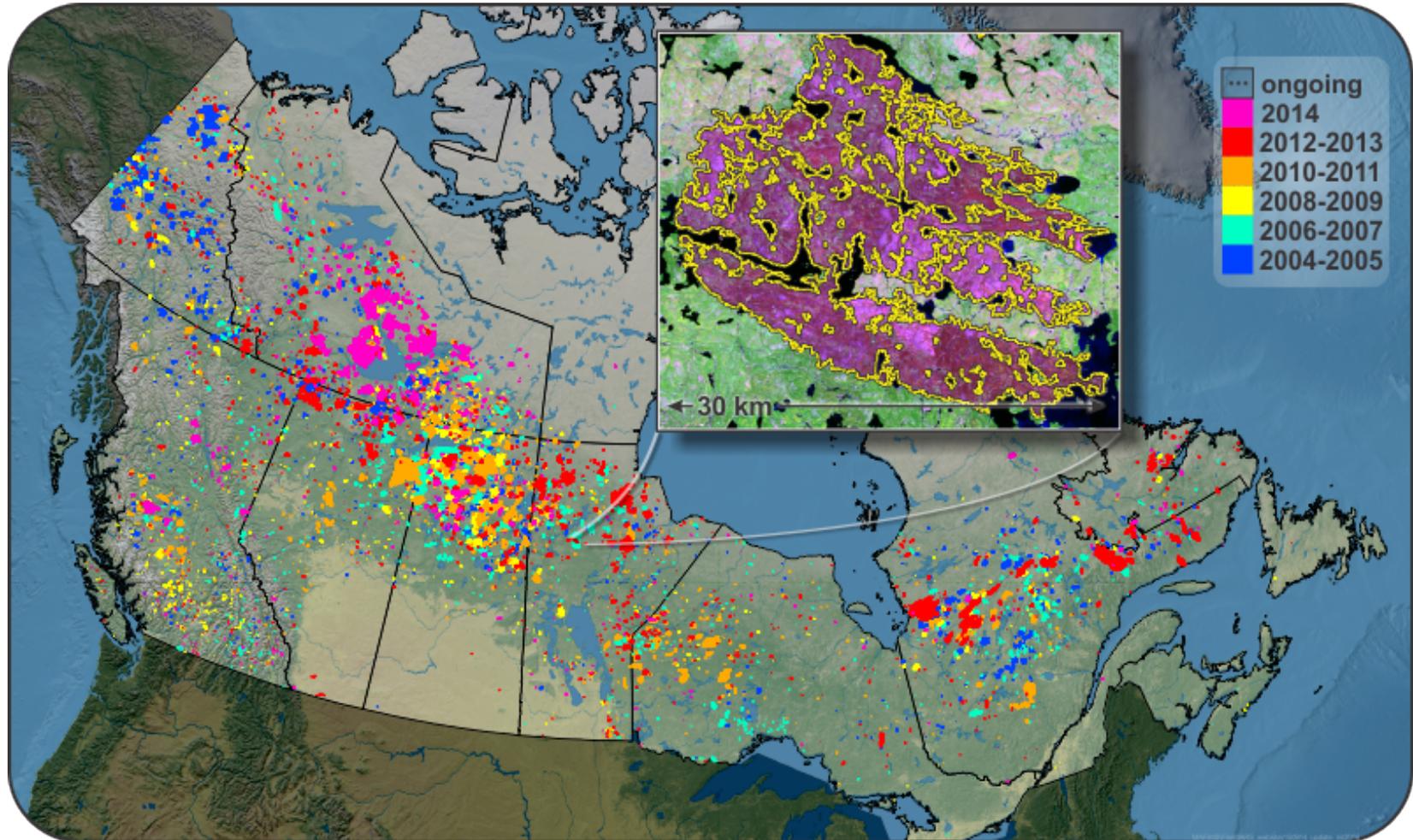


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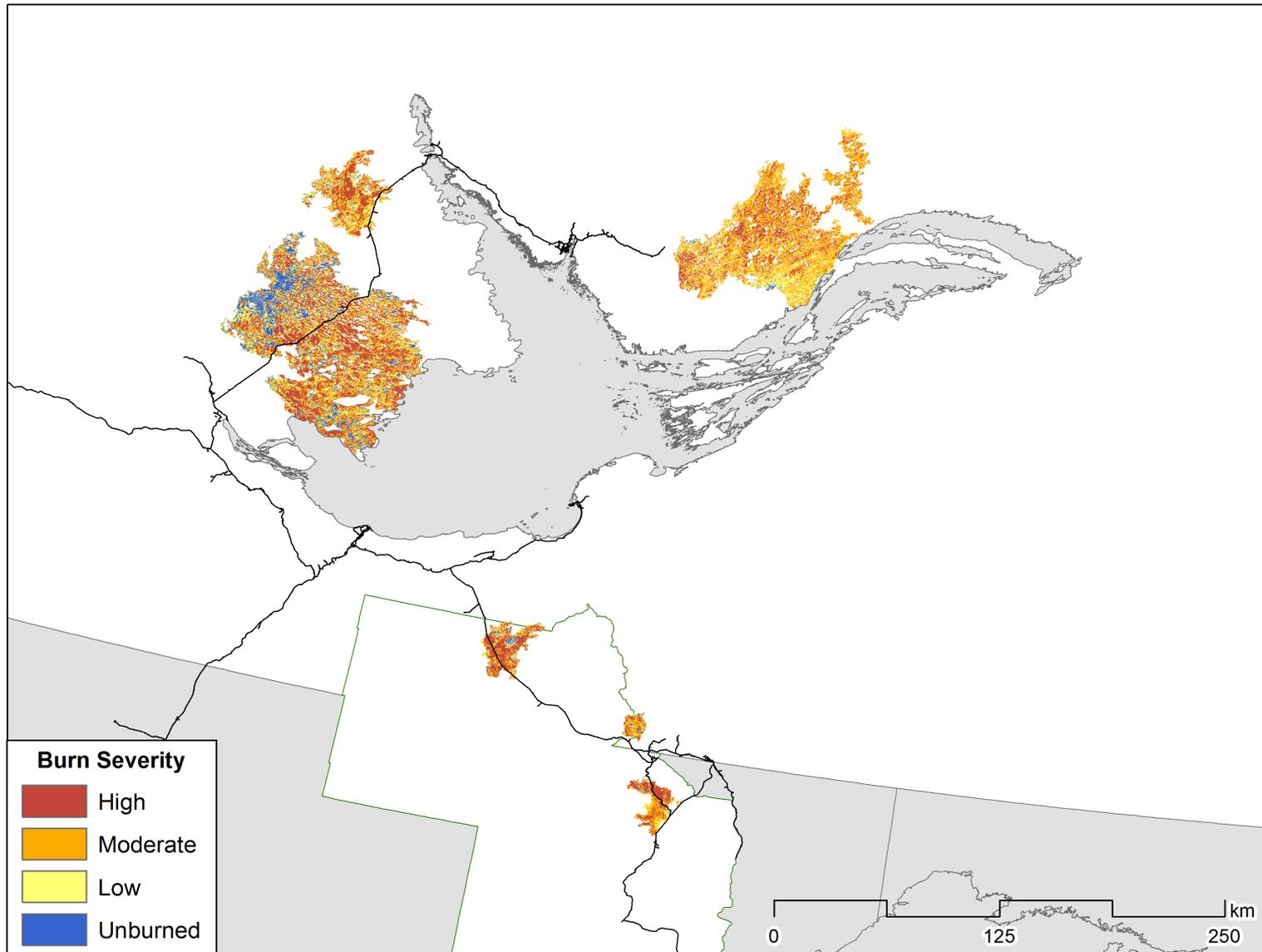
# Canadian Upland Forest Soil Carbon Database (n = 3480) (Shaw et al.)



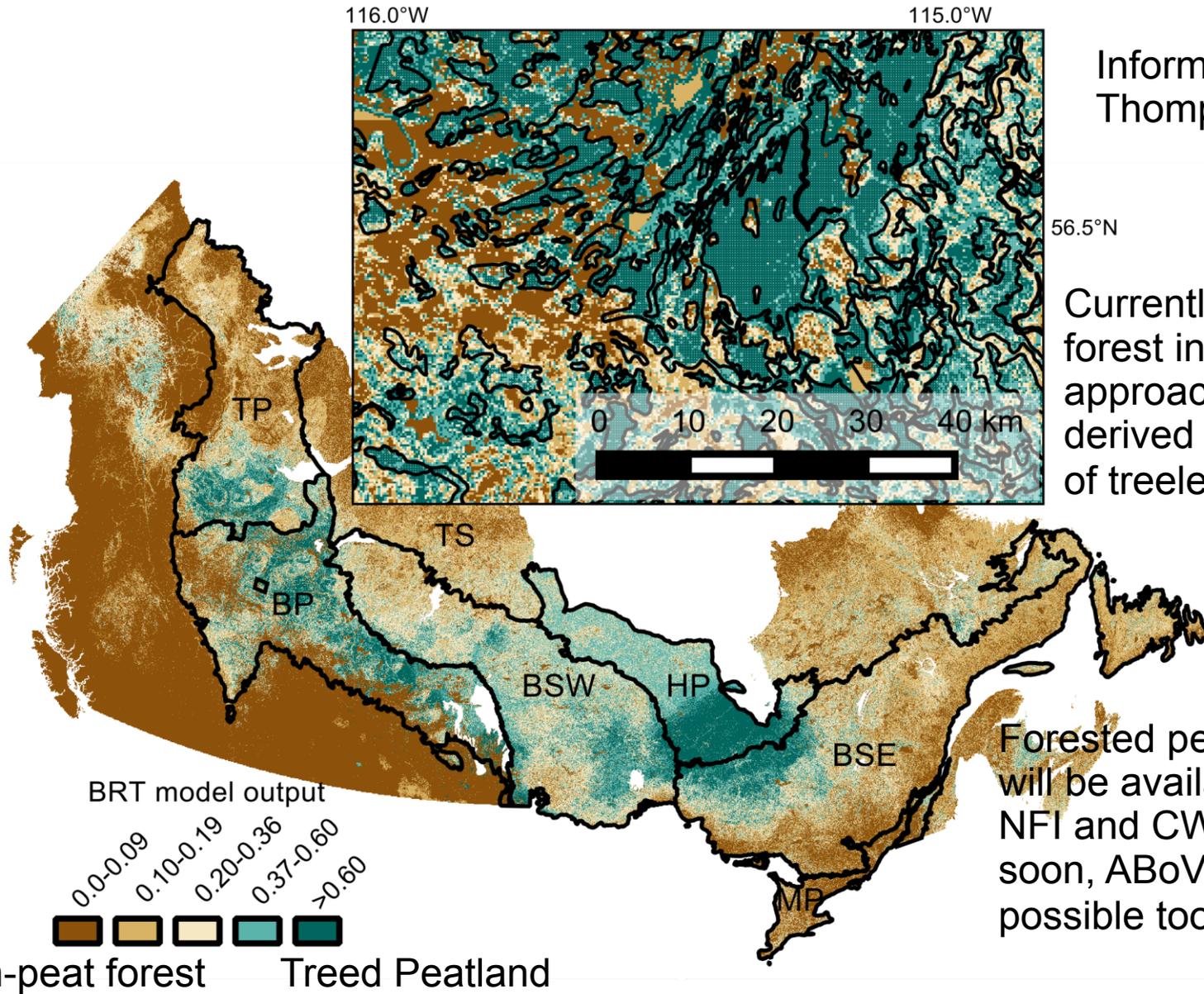
# Mapping Fires: National Burned Area Composite (R. Hall et al.)



# Burn severity mapping (Whitman et al.)



# Mapping forested peatlands using forest inventory data



Information from Dan Thompson

Currently combining this forest inventory-derived approach with LANDSAT-derived EOSD mapping of treeless peatlands

Forested peatland map will be available through NFI and CWFIS datamarts soon, ABoVE science cloud possible too



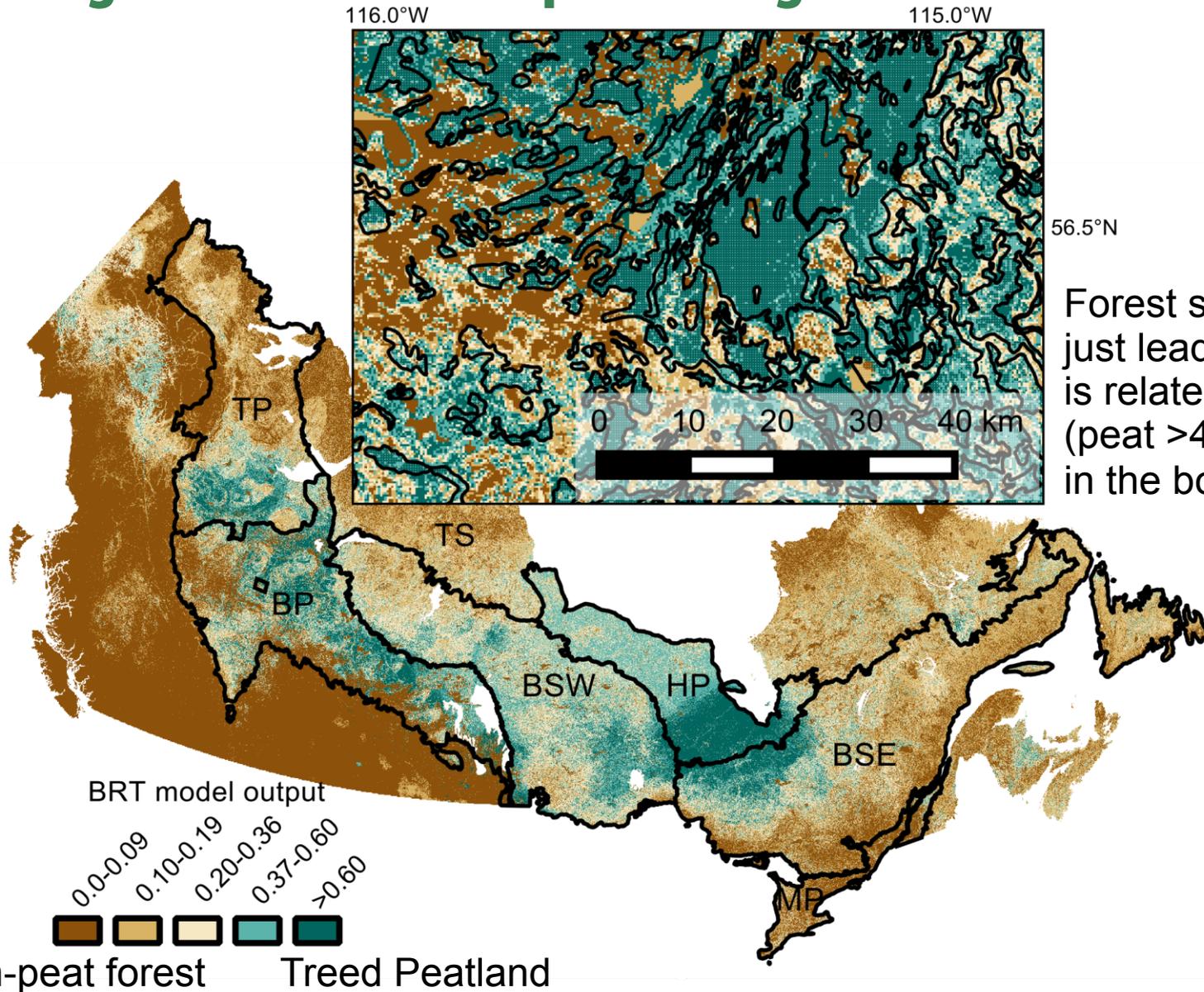
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Thompson et al. *Forest Ecol. Man* (In Press)

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# Using fuels structure to predict organic soils



Forest structure, not just leading species is related to peatland (peat >40cm) occurrence in the boreal



# CIPHA study

## Climate Impacts on Productivity & Health of Aspen

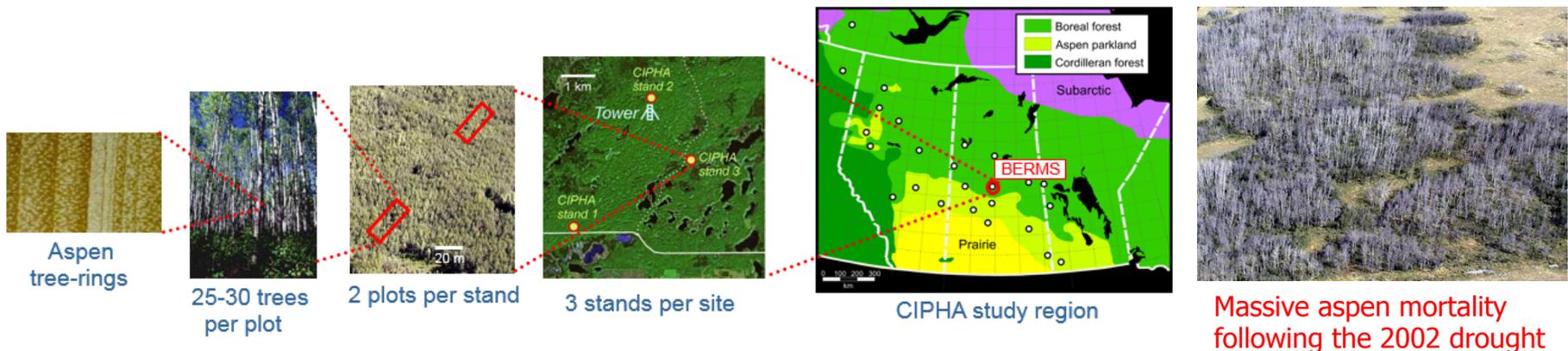


**Aim: Provide knowledge of how severe drought & its interactions with forest insects & diseases affect aspen stand dynamics across multiple scales**

- Methods include tree-ring analysis, annual plot-based measurements & remote sensing
- Initiated in 2000 by Canadian Forest Service & Environment Canada
- Proposed re-measurement in 2016 through partnership with 2 provinces (Alberta & Sask.)

### Key publications

Hogg et al. 2002, 2005, 2008 (CJFR); Michaelian et al. 2011 (GCB); Hogg & Michaelian 2015 (GCB)



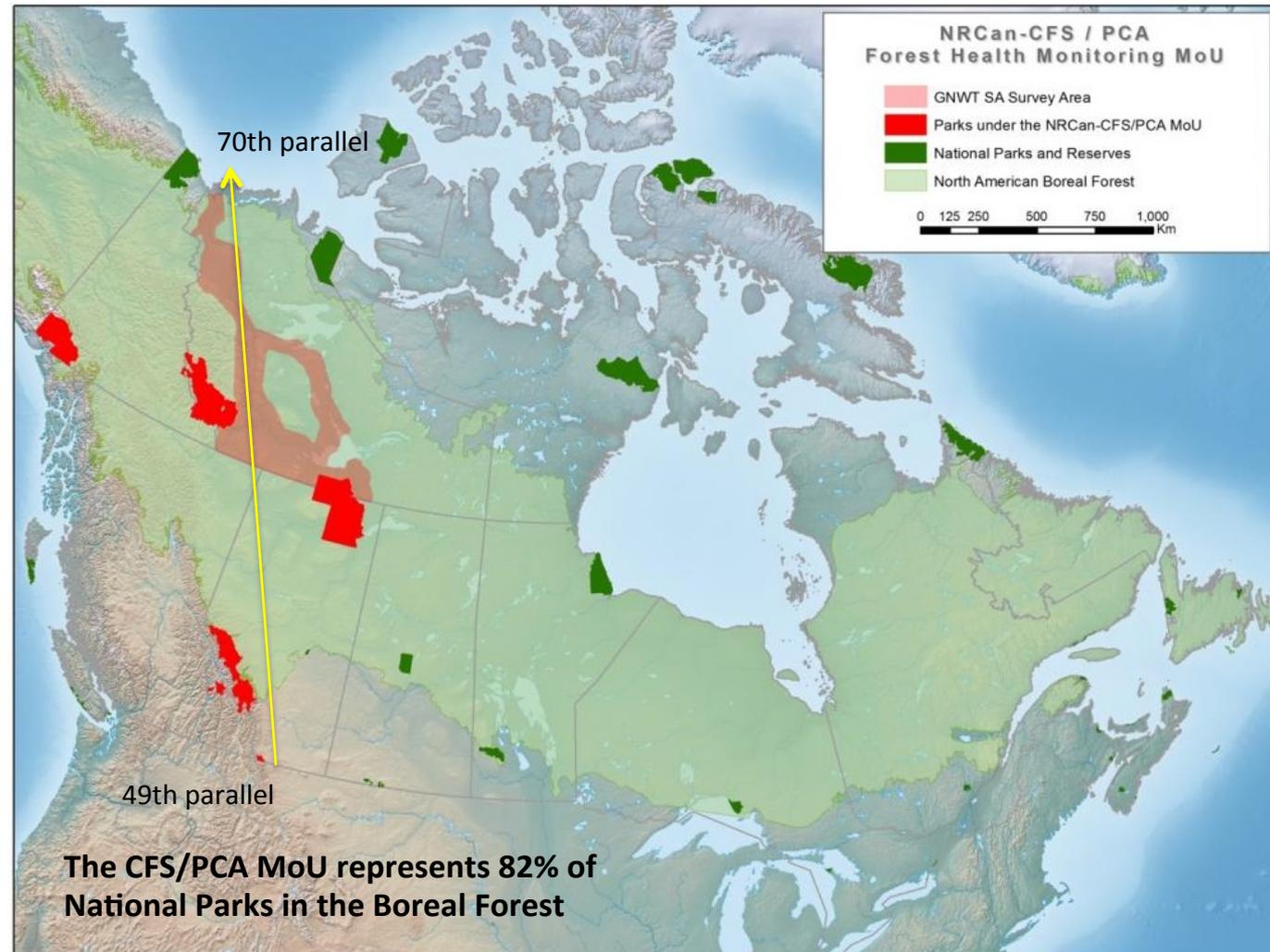
# Northern and high-elevation Forest Health monitoring projects

## NWT & Parks Canada Forest Health Monitoring

**What we do:** Annual surveys (aerial and some ground) to assess current forest health conditions, observe trends over time, and discover emerging issues.

**What we see:** Climate-related Forest Health observations have been increasing in scope, especially over the last decade. Direct and indirect damage due to drought and the ongoing warming trend.

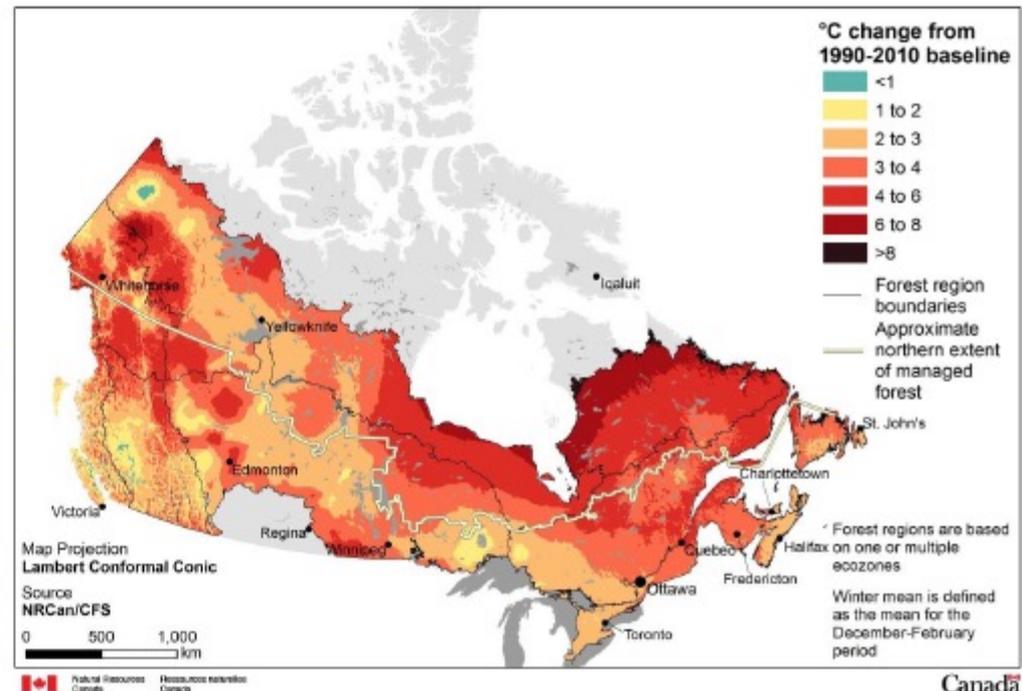
**How can we help:** We have pest survey data dating back to 1954. Observations can direct attention to areas of concern or help confirm remotely-sensed issues.



# Climate change projections (D. Price & D. McKenney)

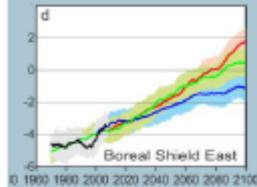
- Downscaling of IPCC AR5
  - ANUSPLIN
  - BIOSIM
- 3 time periods
  - short-term (2010-2040)
  - medium-term (2040-2070)
  - long-term (2070-2100)
- 3 GHG emissions scenarios:
  - RCP 2.5 (low scenario),
  - RCP 4.5 (medium scenario)
  - RCP 8.5 (high scenario)
- Six variables: Tmin/max, Precip., Solar Rad., Wind, Vapour
- 10 km gridded data
- Canadian CGM

2071-2100 | Long-term | RCP 2.6 | Projected changes in winter mean temperature



# Vulnerability of Tree Species to Climate Change (Aubin et al.)

CLIMATE  
SCENARIOS  
D. McKenney &  
team



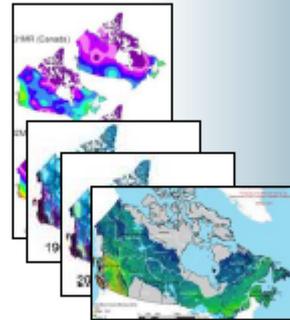
CLIMATE  
MOISTURE  
INDEX  
T. Hogg & team



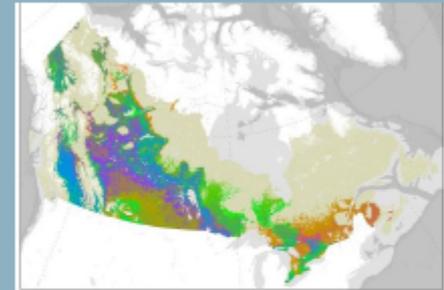
STAND  
COMPOSITION  
A. Beaudoin &  
team



SPECIES  
TRAITS  
I. Aubin & team



INTEGRATED  
INFORMATION  
PRODUCTS  
I. Aubin & collab.



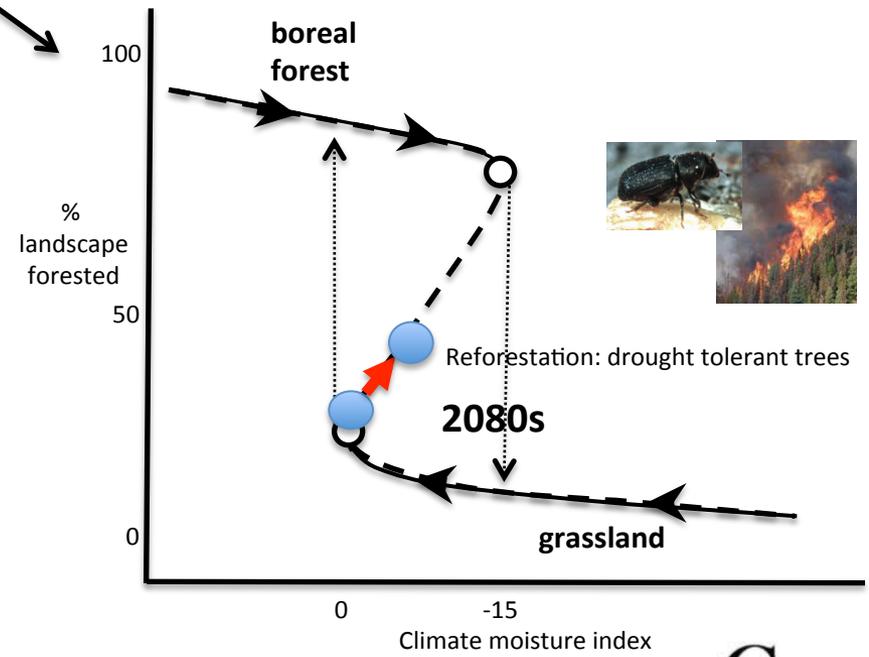
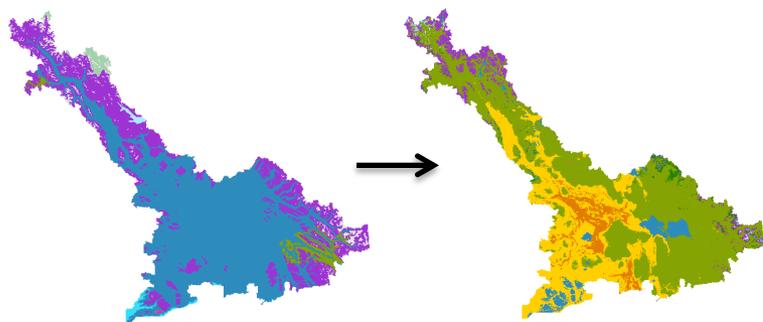
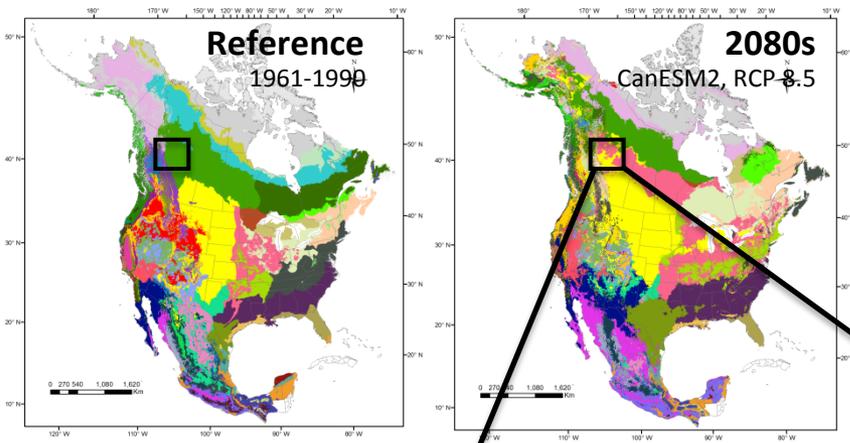
Sensitivity to drought of  
at-risk wood volume  
2071-2100

Potential Uses

- Multifaceted vulnerability assessment
- Integrating ecological knowledge with biophysical projections
- Creating value-added products from existing datasets



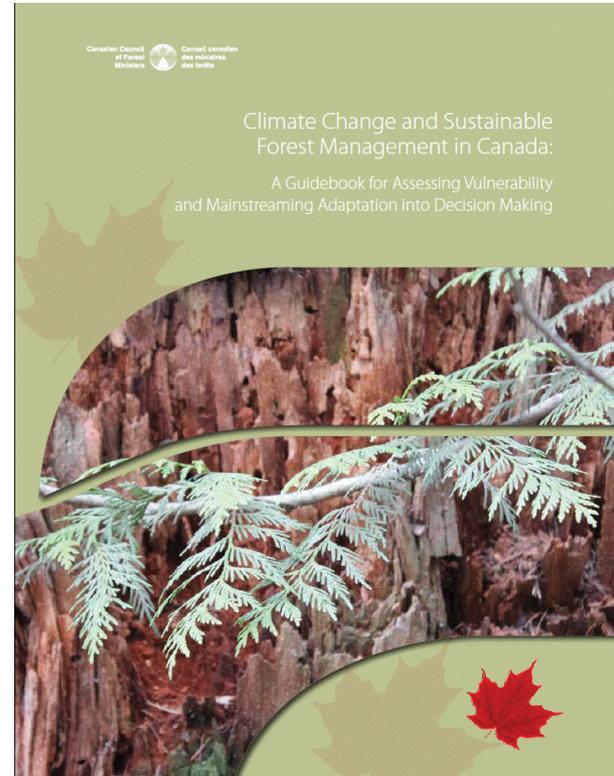
# Forecasts: changes in ecosystem structure/function (Campbell, Price, Hogg, et al.)



# A Guidebook for Adapting Sustainable Forest Management to Climate Change (Edwards et al.)

## The “How-To Adapt” Manual

Follows a Vulnerability  
Assessment Approach



[www.ccfm.org](http://www.ccfm.org)  
– climate change link –



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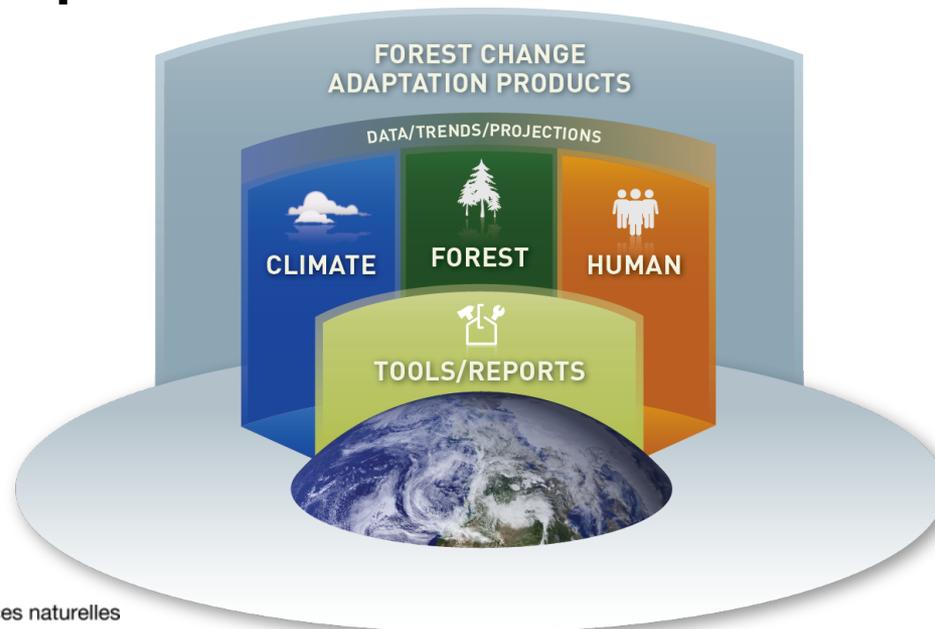
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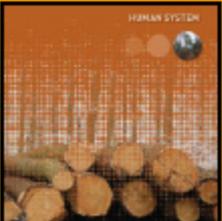
# CFS Forest Change Initiative

Building on existing capacity, knowledge and expertise...

- 1. A Tracking System that reports on indicators of climate change impacts to identify forest sector vulnerabilities**
- 2. An Adaptation Toolkit of actionable science for sustainable forest management under a changing climate**
- 3. Integrated Assessment of climate change implications for the forest sector to guide policies and investment**



# Forest Change Tracking System - Indicators

System	Dimension	Indicator
<b>Climate</b> 	Drought	<ul style="list-style-type: none"> <li>• Climate Moisture Index (CMI)</li> <li>• Palmer Drought Severity Index (PDSI)</li> <li>• Soil Moisture Index (SMI)</li> </ul>
	Fire weather	<ul style="list-style-type: none"> <li>• Start+ End + Length of Fire Season</li> </ul>
	Growth conditions	<ul style="list-style-type: none"> <li>• Length of Growing Season</li> </ul>
<b>Forest</b> 	Tree species distribution	<ul style="list-style-type: none"> <li>• Distribution of Tree Species</li> </ul>
	Fire regime	<ul style="list-style-type: none"> <li>• Annual Area Burned</li> <li>• Number of Large Fires</li> </ul>
	Tree mortality	<ul style="list-style-type: none"> <li>• Percent annual loss of living tree biomass</li> </ul>
	Pest Incidence	<ul style="list-style-type: none"> <li>• Pest Species Distribution</li> </ul>
	Forest Growth	<ul style="list-style-type: none"> <li>• Radial Growth Trends</li> </ul>
<b>Human</b> 	Phenology	<ul style="list-style-type: none"> <li>• Timing of Budburst</li> </ul>
	Cost of Fire Protection	<ul style="list-style-type: none"> <li>• Wildfire suppression Resource Expenditures</li> </ul>
	Wildfire evacuations	<ul style="list-style-type: none"> <li>• Number of evacuations &amp; evacuees</li> <li>• Evacuations location</li> <li>• Number of home losses</li> </ul>
	Wildland Urban Interface	<ul style="list-style-type: none"> <li>• Population at risk of forest fire</li> </ul>
	Transportation	<ul style="list-style-type: none"> <li>• Freeze-thaw of winter roads</li> </ul>

# CFS Needs

- **More data for our northern forests**

**Forest Inventory**

**Species distributions**

**Weather data**

**Soil properties**

- **Assistance with tracking change**

**Regeneration**

**Phenology (forest pests, bud break)**

**Tree mortality**

**Vegetation change**

- **Increased understanding of disturbances**

**Interactions between disturbances**

**Changes in disturbance regimes**

- **Socio-economic research for northern forest-based communities**



# Opportunity

- **There is a clear opportunity to improve efficiency via complementarity of efforts and improved coordination between data collection and engagement activities.**

